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Contribution from the Bureau of Entomology, L. O. Howard, Chief.

WIREWORMS DESTRUCTIVE TO CEREAL AND FORAGE CROPS.

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INTRODUCTION.

The purpose of this bulletin is to enable farmers to distinguish between the different kinds of wireworms, so that they can make use of the method shown to be best in the control of each. It is apparent from several years of investigations into the habits and life histories of wireworms that many of the so-called wireworm remedies are of little or no value. Wireworms occur practically everywhere and attack a great variety of crops, and the character of the damage produced is similar in most cases and usually necessitates a reseeding or replanting.

The species here treated are the wheat wireworm [1] of the Northeastern and Middle Western States, the corn wireworms [2] of the Middle Atlantic and New England States and the Mississippi Valley, the meadow wireworms (including the sugar-beet wireworm [3] and the confused wireworm [4]), the corn and cotton wireworm [5] of the Southern States, and the dry-land wireworm [6] and inflated wireworm [7] of the dry-farming region of the Northwest and the wheat regions of the Northern Middle West.

[1] *Agriotes mancus* Say.
[2] *Melanotus communis* Gyll. and other species of Melanotus.
[3] *Limonius californicus* Mann.
[4] *Limonius confusus* LeC.
[5] *Horistonotus uhleri* Horn.
[6] *Corymbites noxius* Hyslop.
[7] *Corymbites inflatus* Say.

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KINDS OF WIREWORMS, AND WHERE FOUND.

Wireworms are the young or worm stage of several kinds of hard-shelled beetles popularly known as "click-beetles," "skipping jacks," "snapping beetles," etc. These names are all derived from the beetles' unique habit of snapping the forepart of the body when placed on their backs or held between the fingers. This habit is undoubtedly of use to the beetles in righting themselves when accidentally overturned and may also be a means of escape from their natural enemies. Wireworms are elongate, more or less cylindrical, and have a very highly polished skin. They measure, according to kind, from one-half inch to 3 inches in length. They have three pairs of short legs near the head end of the body. The color usually is yellow or reddish brown. The cotton and corn wireworm (fig. 4) is very different in appearance from all other wireworms.

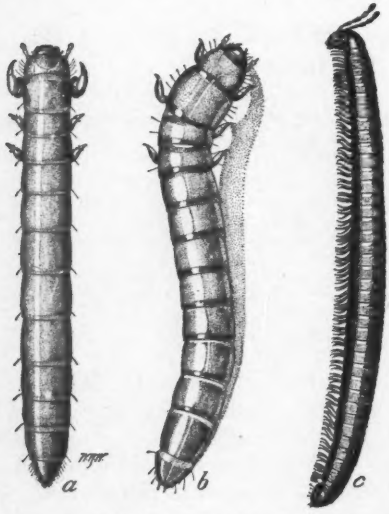

FIG. 1.—Larvæ likely to be mistaken for wireworms; *a*, False wireworm; *b*, mealworm; *c*, "thousand legger." All enlarged. (Author's illustrations.)

The name wireworm is erroneously applied to the false wireworms of the Western States (fig. 1, *a*), and the mealworms found in granaries (fig. 1, *b*). In many parts of the country root webworms also are wrongly called wireworms, and the name is incorrectly applied to several kinds of "thousand leggers" (fig. 1, *c*).

True wireworms are among the five worst pests to Indian corn and among the 12 worst pests to wheat and oats. They are also important enemies to many other crops, notably potatoes and sugar beets. They constitute a group which is probably one of the two most difficult groups of insects to control. In the last part of this bulletin the results of recent investigations as to control measures are set forth.

These insects are destructive to cereal and forage crops in the larval or worm stage only, although the beetles of some kinds do considerable damage to the blossoms of fruit trees. Wireworms attacking cereal and forage crops confine their attention to the seeds, roots, and underground stems and live almost exclusively underground. The damage is first noticed immediately after seeding, when they attack the seed, eating out the inside and leaving only the hulls.

This, of course, results in a poor stand. In such cases, by digging into the hill, the wireworms may be located. When they are very numerous they often consume an entire seeding, and, aside from the extra labor and the cost of reseeding, this delays injuriously the planting of the crop. If this be corn in the Northern States, the part of the season remaining is too short to bring it to maturity, and, except for the fodder, the crop is a failure. Where wireworms are present, even in small numbers, corn usually makes a poor stand, so that the replanting of missing hills is necessitated.

Several hundred kinds of beetles, the young of which are wireworms, occur in North America. Many of these, however, are of little immediate importance to the farmers, as they live in rotten logs, under moss, or on the roots of weeds, or prey upon other insects. The destructive wireworms are found in nearly all parts of the United States. Some of these, such as the wheat wireworm and the corn wireworm, abound in heavy moist soils rich in vegetable matter. Some, as the inflated wireworm and the dry-land wireworm, prefer well-drained soils, and still others, like the corn and cotton wireworm, are most destructive on high sandy land which is very poor in vegetable matter. As the several kinds of wireworms have such varying habits they can not all be controlled in the same way, and a variation in method is required for each of the several groups. For this reason it is quite necessary to be able to determine what kind of wireworm is doing the damage.

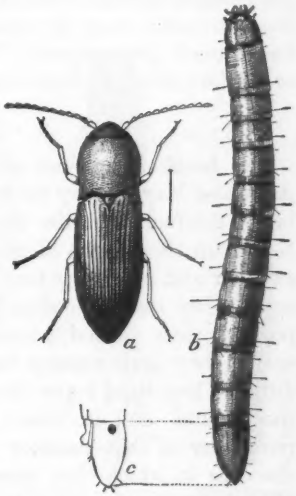

FIG. 2.—The wheat wireworm: *a*, Adult beetle; *b*, larva; *c*, side view of last segment of larva. All enlarged. (From Chittenden.)

THE WHEAT WIREWORM.

The adult, or beetle, of the wheat wireworm is brown and a little over one-fourth inch in length (fig. 2, *a*). The wireworm itself (fig. 2, *b*) is pale yellow, evenly cylindrical, and very shiny. When full grown it measures about 1 inch in length and is about as thick as the lead in a pencil. This wireworm can be easily recognized by the two dark spots near the base of the tail (fig. 2, *c*), and it is one of the commonest wireworms in the northeastern and middle-western United States. It is normally a grass feeder, living on the roots in

sod, and when its natural food supply is abundant it produces no appreciable disturbance in the meadows. When the sod land is broken, however, these wireworms gather in the drill rows or hills of corn, which is the usual crop to follow sod in the eastern United States, and often cause an absolute failure of the crop by destroying the seed and eating off the roots of such plants as may sprout. They also sometimes bore into the underground part of the stem of the plant. This wireworm is, therefore, usually more destructive on land recently broken from sod. However, in many cases the damage is more severe the second year following plowing from sod than the first. This is probably due to the fact that the wireworms feed upon the recently turned-down sod the first year, but are forced to attack the cultivated crop the second year, because by that time the sod has entirely decomposed. The wireworms spend three years in the soil before changing to beetles.

LIFE HISTORY.

The beetles come out of the ground in the early spring, during April and May. They then fly about and deposit their eggs in grass-lands, the female beetles burrowing into the ground or under rubbish to deposit their eggs. The young wireworms feed during the ensuing summer and pass their first winter about half grown. The following spring they resume feeding and feed throughout the second summer, passing their second winter as full-grown wireworms. The third spring they again resume feeding, which they continue until early in July. They then leave the plants and form small earthen cells in the ground, and in these they transform to beetles. During the remainder of that summer and the third winter the beetles stay in the cells in which they transformed; then, during the fourth spring of their life they come out of the ground to lay their eggs.

CROPS ATTACKED.

The wheat wireworm feeds upon the seeds and roots of corn, potato tubers, wheat roots, carrots, turnips, and the underground stems of string beans, cucumbers, and cabbage, more or less seriously damaging or destroying the same.

REMEDIAL MEASURES.

When the land is intended for corn the following year, in order to counteract the ravages of the wheat wireworm, sod land should be plowed immediately after the first hay cutting, usually early in July. This land should be cultivated deeply throughout the remainder of the summer. Land that is in corn and badly infested should be deeply cultivated, even at the risk of slightly root-pruning the corn.

This should be continued as long as the corn can be cultivated, and as soon as the crop is removed the field should be very thoroughly tilled before sowing to wheat. In regions where wheat is seeded down for hay, any treatment of infested wheat fields is precluded. Where wheat is not followed by seeding to other crops, the field should be plowed as soon as the wheat is harvested; this kills the worms by destroying their food supply and preventing proper hibernation.

A thorough preparation of the corn land and a liberal use of barnyard manure or other fertilizer will often give a fair stand of corn in spite of the wireworms, a vigorous stand often being able to produce roots enough to withstand the depredations of several wireworms. Though not always practicable, the interposing of crops not severely attacked by wireworms, such as field peas and buckwheat, between sod and corn would materially reduce the number of wireworms in the soil at the time the crop is planted.

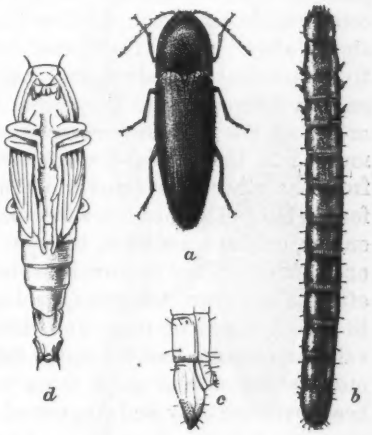

FIG. 3.—One of the corn wireworms: *a*, Adult; *b*, larva *c*, last segments of same; *d*, pupa. All enlarged. (From Chittenden.)

THE CORN WIREWORMS.

The beetles of the corn wireworms (fig. 3, *a*) measure from one-half to three-fourths inch in length, and they vary in color from light reddish brown to almost black. The wireworms (fig. 3, *b*) are reddish brown, about 1¼ inches long, cylindrical in shape, and always have three slight lobes or projections on the tail. These wireworms are pests to cereal and forage crops in the Middle Atlantic States, the New England States, and the Mississippi Valley.

LIFE HISTORY.

The beetles of these wireworms emerge in the spring and deposit their eggs in grasslands. The corn wireworms, however, spend a considerably longer time in the soil than the wheat wireworms. In some cases the corn wireworms live in the ground as long as six years. They change to beetles during August, and some beetles spend the following winter in the cell in which they transform. The beetles of some kinds of corn wireworms apparently spend the winter under the bark of decaying trees.

REMEDIAL MEASURES.

The corn wireworms are almost exclusively confined to poorly drained and heavy soils. Heavily liming and thoroughly tile-draining land infested with these wireworms would undoubtedly prove beneficial. The thorough cultivation of waste land, especially along drainage ditches and creeks, during midsummer, and the deep cultivation of crops and fallow land at the same time would destroy large numbers of them.

THE MEADOW WIREWORMS.

The meadow wireworms, including the sugar-beet wireworm and the confused wireworm, do far more damage than they are generally given credit for. In the Pacific Northwest they damage corn and potatoes and other truck crops. They have also been found doing considerable damage in the New England States and the upper Mississippi Valley. In the Northwest they seem to be much more destructive on irrigated lands than on the dry-farming lands, while in the eastern United States they seem to be confined to poorly drained areas, as are the corn wireworms. Meadow wireworms look very much like the dry-land wireworm and can be easily distinguished from the other wireworms which are important as crop pests by the forked tail. The meadow wireworms attack corn, potatoes, tomatoes, onions, cabbage, radishes, turnips, horse-radish, spinach, sugar beets, and alfalfa. They burrow into the underground parts of the plants, often killing corn, tomatoes, cabbage, or onions. They do not seem to attack beans or peas, and these crops might be of considerable value in clearing badly infested fields prior to seeding to corn. The meadow wireworms spend three years in the ground and change to beetles during July and August of their third summer.

REMEDIAL MEASURES.

Thorough tile draining of infested fields in the eastern areas and deep cultivation during July and August wherever possible will destroy large numbers of these wireworms. As most of this poorly drained land is inclined to be acid, the tilth will be greatly improved by the addition of lime at the rate of about 2 tons to the acre, using air-slaked lime. The use of lime, however, has been treated very fully in both Government and State publications, and it would be advisable for the farmer to apply to the State or Federal authorities for the rate and kind of lime to use in his particular case.

On irrigated land experiments are being made to determine remedial measures.

THE CORN AND COTTON WIREWORM.

The beetle of the corn and cotton wireworm (fig. 4, *a*) is small, cylindrical, and dusky brown, measuring a trifle over three-sixteenths inch in length. The "worm" (fig. 4, *b*) is very unlike any of the other wireworms. It is not hard and wiry, but soft and elongate. The body usually is white and apparently is composed of 26 joints.

When full grown this wireworm is about as thick as a heavy packthread. Unlike most of the eastern wireworms, which are usually most destructive on low-lying, heavy, or poorly drained lands, this wireworm seems to be far more numerous on the higher parts of the field in light sandy soils. The corn and cotton wireworm is one of the most troublesome pests of the southern United States. Bad outbreaks have occurred in the Carolinas, Missouri, Arkansas, and southern Illinois. Corn, oats, rye, cowpeas, crab grass, Johnson grass, peanuts, cotton, tobacco, sweet potatoes, and watermelons are all attacked, corn suffering the most of all. Investigations are now under way to determine efficient remedial measures for this insect.

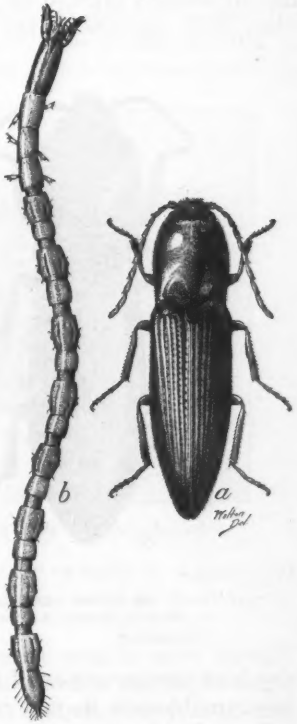

FIG. 4.—The corn and cotton wireworm: *a*, Adult beetle; *b*, larva. Enlarged. (Author's illustration.)

THE DRY-LAND WIREWORM AND THE INFLATED WIREWORM.

The dry-land wireworm (fig. 5) and the inflated wireworm, which are very similar in appearance, seem to be confined to the dry-farming regions of the Northwest and to the wheat regions of the northern Middle West. Early in May the beetles emerge from the ground. They are about in large numbers during May and in June, when the females burrow into the ground to deposit their eggs. These wireworms do not confine their egg laying to grasslands, but deposit the eggs in grain fields and weedy fallow lands. The wireworms spend two full summers and a part of a third in the ground, transforming to beetles during July and August of the third summer, the beetles not coming from the ground until the fourth spring. Thus the wireworms, as such, are in the ground during the growing season of three years. The beetles of the inflated wireworm have been observed in large numbers on the blossoms of wild rosebushes, where they were apparently eating the petals. The beetles of the dry-land wireworm are a little later in coming out of the ground, emerging in June and July. In the dry-land regions this wireworm feeds only during the spring, burrowing down from 4 to 8 inches below the surface to pass the hot, dry months.

REMEDIAL MEASURES.

As will be seen from the life history, the generations about to become adults are inactive wireworms from June to August, transforming to beetles in the early part of August. The resting and transforming wireworms usually are found at a depth of 4 to 8 inches, and any disturbance of the soil to such depth at this time will destroy them. The ground is very hot during this period of the year, and the air extremely dry, so that even the resting wireworms that are not actually crushed by the cultivation soon succumb to drying when their cells are broken open. The usual farm practice in the

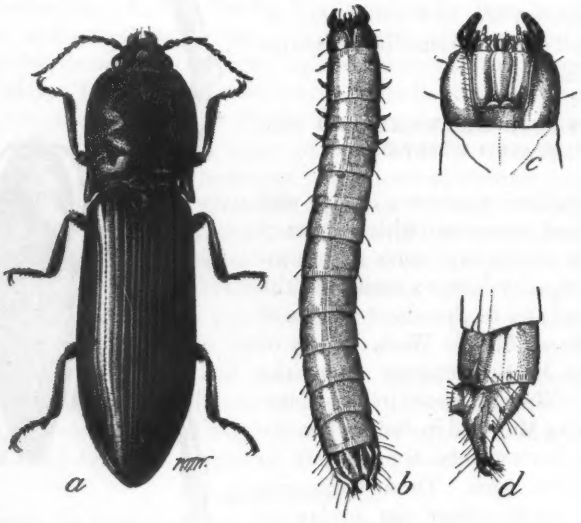

FIG. 5.—The dry-land wireworm: *a*, Adult; *b*, larva; *c*, under surface of head of larva; *d*, side of last segment of larva. *a*, *b*, Enlarged; *c*, *d*, more enlarged. (Author's illustration.)

dry-land farming region of the Northwest where these wireworms are most troublesome may be roughly outlined as follows:

Immediately after seeding the wheat in early spring the summer fallow land is plowed to a depth of from 4 to 7 inches. This usually is done in April, but if horses and help can be spared from seeding, the summer fallow is plowed as early in the spring as the land can be worked. The next operation on the fallow land is disking the land in June or early July to maintain the dust mulch and kill the weeds and volunteer wheat. Some of the more progressive farmers now practice fall plowing of the stubble and disking the fallow land only in the spring. The field is disk-harrowed early in the spring if the land has run together during the winter and is caked, otherwise the land is harrowed with a drag or spring-tooth harrow. It is then

seeded and dragged and receives no further treatment until harvest. The seeder usually is set to sow at a depth of about 3 inches, although, if the moisture content is high enough, 1 inch is considered sufficient. Wheat hay is used extensively in this country, and is cut while the wheat is in the dough stage, which usually is from July 4 to July 15. The wheat crop is harvested from August 1 to September 15. In order to destroy wireworms this practice should be altered in the following manner:

(1) Disk or drag-harrow the summer fallow as early as possible in the spring in order to produce a dust mulch and thereby conserve the accumulated winter moisture. (2) Continue the disking as often as is necessary in order to maintain the dust mulch and keep down the

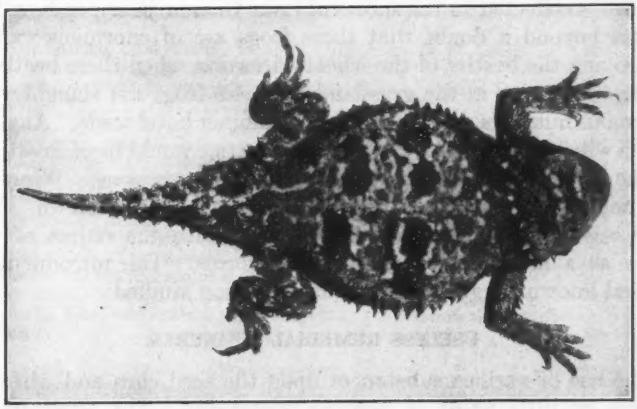

FIG. 6.—A horned toad, an enemy of the western wireworms. (Author's illustration.)

weeds. (3) Plow the summer fallow in July or early in August and immediately drag. (4) Plow the stubble as soon as the crop is removed.

As these wireworms are of three different ages in most infested fields, and as only about one-third of these are in the pupal stage, changing to beetles each year, it is evident that the first year of this practice will not show marked results. However, if the practice is continued for two years it will reduce the number of these pests very considerably. Aside from its beneficial results in killing insects, this method of handling the land will materially reduce the weeds, the early disking merely softening up the soil and allowing all the weed seeds present to sprout, the entire crop of weeds subsequently being destroyed by the summer plowing. By the present method of farming, the weed seeds are turned down to such a depth that many can not germinate; but they lie dormant, and sprout whenever they happen

to be brought to the surface by subsequent cultivation. One crop of weed seed is in this manner often a pest for several succeeding years.

NATURAL ENEMIES OF WIREWORMS.

Most of our common song birds feed rather extensively upon both the beetles and the wireworms themselves, and any regulation designed to protect these birds and encourage their increase will undoubtedly be effective in reducing the number of these pests. In the desert regions of the West the small lizards, commonly called sand toads or horned toads (fig. 6), feed very extensively upon wireworms and their beetles and should be protected by the farmers of these regions. The examination of the stomachs of a large series of field frogs collected on the shores of Lake Oneida, in upper New York, proves beyond a doubt that these frogs are of enormous value in destroying the beetles of the wheat wireworm when these beetles are laying their eggs in the grasslands. These frogs are slaughtered in enormous numbers every year for the summer hotel trade. Any regulation which would put a stop to this practice would be of great value to the agricultural interests of this and similar sections. Wireworms are not severely attacked by parasites, so far as is known. However, several parasites are being studied with the object of using them as a means of controlling wireworms. The introduction of several known fungous diseases also is being studied.

USELESS REMEDIAL MEASURES.

The use of various substances upon the seed corn and wheat has proven of little value in fighting wireworms. The application of certain commercial fertilizers recommended as insecticides is also of but little use. The application of lime is not effective as an insecticide, but is of value in rendering the soil more easily drained. Late fall plowing has probably been the most universally recommended method of combating these insects. However, at least for the kinds of wireworms on which this method has been tried, it is quite useless. Trapping the larvæ with baits of poisoned vegetables may be of some value under intensive methods of farming, but it is impracticable in the growing of field crops.

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